4. VACUUM SYSTEM

For convenience, the RHIC vacuum system is divided into four regions. These comprise: 1) the cold-bore UHV system, housed within the bore and at the interconnects of the superconducting magnets; 2) the conventional warm-bore systems residing between the cryostats and within the magnets, in the special case of the DX magnets; 3) the cryostat vacuum systems, serving as the guard vacuum for the superconducting magnets, and operating at pressures $\leq 10^{-5}$ Torr; and, 4) the special experimental regions, having their own unique vacuum materials and pressure requirements.

i. Beam Vacuum

The RHIC machine, must store two counter-rotating particle beams for periods of greater than ten hours. Colliding beams may comprise protons, gold ions (i.e., Au^{+79}), or a wide variety of heavy ions, colliding with each other or protons.

First, the intensity, and thus usefulness, of the particle beams is diminished when the stored particles are lost from their contrived orbits either due to charge exchange processes or through nuclear scattering with background gas. Secondly, particle beam collisions with gas in regions near the experimental detectors cause background noise in these detectors, and are therefore undesirable. For these reasons, a low operating pressure in the RHIC is very important. The RHIC rings, illustrated in Fig. 4-1, comprise separate 3.8 km circumference rings. About seventeen percent of the life of each beam is spent in *warm*, RT (i.e., room temperature) sections of the rings; the remainder is spent in beam pipes operating at a temperature of ~4.2 K (i.e., the *cold-bore*). Based on calculations by Rhoades-Brown and Harrison,[1] an average total pressure of 5×10^{-10} Torr is required in the warm sections, the gases comprising 90% H_2, 5% CO and 5% CH_4. However, the pressure specification for beam components such as kickers, septum and RT rf cavities is $\leq 2\times10^{-9}$ Torr, and in the above gas species proportions. This implies that the warm-bore sections

[1] M. J. Rhoades-Brown, M. Harrison, *Vacuum Requirements for RHIC*, Informal Report AD\RHIC-106, BNL #47070 December 1991.

of the ring not occupied by beam components must operate in the pressure range of $1\text{-}2\times10^{-10}$ Torr. The requirement for the average total pressure of the cold-bore is $\leq10^{-11}$ Torr, comprising exclusively H_2 and He.

Based on the cited calculations, the emittance growth of a gold beam, at $\gamma = 100$ and due to elastic scattering in the warm sections, will be 1.13×10^{-4} mm mrad per hour, and 2.4×10^{-4} mm mrad per hour in the cold-bore sections. Also, beam lifetimes (i.e., one *e-fold* decrease in intensity) due to central nuclear collisions of the gold beam with gas, is given in the cited reference as 600 hours in the warm sections and 242 hours in the cold sections.

Beam neutralization for bunched beams is avoided by self- clearing due to the large spacing of ~200 nsec between bunches. Pressure bump instabilities in the cold-bore are not anticipated based on the experience at HERA and the Fermi Tevatron.

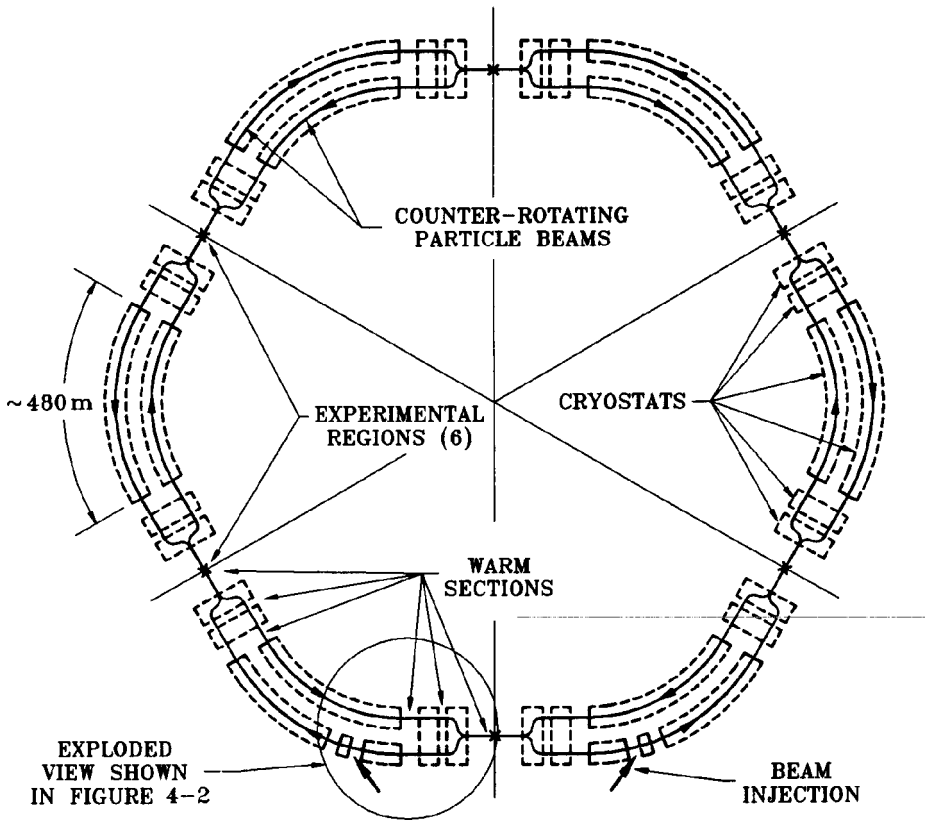

Fig. 4-1. The Brookhaven Relativistic Heavy Ion Collider.